PUBLICATION 476

FARM WATER SUPPLY

Water supply and distribution systems

Ontario
Ministry of Agriculture and Food
Hon. Ed Biddell, Minister

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FARM WATER SUPPLY

Water Supply and Distribution Systems

Soil and Water Management Branch

ABBREVIATIONS USED IN THIS REPORT

Area
m^2 = square metre
ha = hectare

Flow
L/min = litre per minute
L/hr = litre per hour

Length
m = metre
mm = millimetre

Pressure
kPa = kilopascal

Temperature
°C = degree Celsius

Volume
L = litre
ml = millilitre
m^3 = cubic metre

CONVERSION FACTORS

1 inch (in)	=	25.4 millimetres (mm)
1 foot (ft)	=	0.3048 metres (m)
1 acre (ac)	=	0.4047 hectares (ha)
1 square foot (ft^2)	=	0.0929 square metres (m^2)
1 cubic foot (ft^3)	=	0.0283 cubic metres (m^3)
1 gallon (imperial gallon)	=	4.546 litres (L)
1 pound per square inch (psi)	=	6.895 kilopascal (kPa)
(degree Fahrenheit − 32) × 5/9	=	degree Celsius

CONTENTS

	Page
PREFACE	3
INTRODUCTION	4
GROUNDWATER	5
1. Occurrence of Groundwater	5
2. Locating Groundwater	6
3. Permit to Take Water Program	6
4. Water Wells	7
4.1 Drilled Wells	7
4.2 Dug Wells	8
4.3 Reconstruction of Old Dug Wells	8
4.4 Driven and Jetted Wells	8
4.5 Bored Wells	9
4.6 Location of Wells	9
5. Springs	11
SURFACE WATER	12
1. Ponds	12
1.1 Storage Types	12
1.2 Soil Conditions	12
1.3 Topography	12
1.4 Proposed Uses	13
1.5 Storage Requirements	13
1.6 Drainage Area	13
2. Cisterns	13
WATER SUPPLY SYSTEMS	14
1. Pumps	14
2. Electric Motors	15
3. Pressure Switches	15
4. Pressure Tanks	15
5. Air Volume Control	15
6. Selection of Pump and Pressure Tank Capacity	15
7. Installation	17
8. Maintenance	18
9. Trouble Shooting	20
FARM WATER DISTRIBUTION SYSTEM	21
1. Farmstead Distribution	21
2. Distribution Within Buildings	22
3. Outside Outlets	25
REFERENCES	26
LIST OF CONTACTS	27

LIST OF TABLES

Table		Page
1.	Approximate Water Requirements	4
2.	A Comparison of Different Well Types and their Applications	6
3.	Nominal Size of Steel Distribution Pipes	21

LIST OF FIGURES

Figure		Page
1.	A Cross Section of the Earth Showing a Possible Arrangement of Water-bearing Formations	5
2.	Drilled Well Construction	7
3.	Dug Well Construction	8
4.	Driven or Jetted Well Construction	9
5.	Bored Well Construction	10
6.	Spring Protection	11
7.	Illustration of Pump Suction Principle	14
8.	Shallow-well Pumps and their Characteristics	16
9.	Deep-well Reciprocating Pump Installation	17
10.	Deep-well Centrifugal-jet Pump Installation	18
11.	Deep-well Submersible Pump Installation	19
12.	Farmstead Distribution System	22
13.	House Distribution System	23
14.	Frost Free Yard Hydrant	24

PREFACE

This publication is intended as a guide on farm water supply and distribution systems. It should be stressed that this guide is not intended to be used as a manual for well construction nor a manual for pump installation and distribution systems since these require considerable training and experience. Any mention of trade names or commercial products does not constitute endorsement or recommendation for use.

This document is a revision to the Ontario Ministry of Agriculture and Food (OMAF) Publication 476 entitled *Farm Water Supply* which was prepared by F. R. Hore in 1973. For the most part, the document has been kept in the original form. The most noteworthy changes are the conversion of units from imperial to metric, the addition of a Preface, Introduction, a section on the Permit to Take Water Program, and a section on farm ponds. The sections on Groundwater, Surface Water, Water Supply Systems, and Farm Distribution Systems have been slightly modified.

Although water treatment may be an integral part of a farm water supply, it was decided that this section of *Farm Water Supply* should be revised in a separate OMAF Publication 85 entitled *Farm Water Supply — Water Treatment Systems*.

This document therefore focuses on the quantitative aspects of a water supply while recognizing that the quantity available for use may be constrained by its quality.

Sam Singer, P.Eng.
Water Management Coordinator

INTRODUCTION

Water is essential for all biological systems; without it there would be no plant or animal life. The agricultural industry is a major user of fresh water whose needs cannot be ignored.

In Ontario, groundwater is the main source of water for rural domestic use and livestock watering. It is also used, to a lesser degree, to meet some irrigation needs. It is not surprising, therefore, that the quantity and quality of groundwater are two important considerations for viable farm operations.

This publication focuses mainly on the quantitative aspects of groundwater. It provides useful information on the construction of various types of water wells and on the characteristics, selection, installation, and maintenance of pumps. In addition, farm water distribution systems are described. In areas where adequate supplies of groundwater are unobtainable, a surface source such as a stream, lake or pond may be relied upon to meet the farm needs.

Water should be available in quantities to meet all present and anticipated future needs. The total quantity of water required is dependent on the type of farm operation, but generally water usage greatly increases when it is readily available. Modern automatic equipment that requires water is common on the farm and has become a part of everyday living. Table 1 shows the approximate water consumption for various purposes and can be used to estimate the total daily water requirement. For instance, the total daily water requirement for a dairy farm will be 7725 litres where there are five members in the family, 30 head of high producing milk cows, 30 head of heifers and dry cows, and one hour general watering with a 1 cm garden hose.

	litres
5 people @ 225 litres per person	1125
30 milk cows @ 135 litres per head	4050
30 heifers and dry cows @ 55 litres per head	1650
1 hour of hose use	900
Total daily demand	7725

Unfortunately, farm water requirements are the heaviest in the warmest and driest season of the year, when some sources of supply are at their lowest level. It is important, therefore, that a water source be investigated carefully to ensure that it is dependable at all times during the year.

TABLE 1

APPROXIMATE WATER REQUIREMENTS

	litres per day
Member of family (kitchen, laundry, bath)	225
Milk cow (including washing)	135
Beef cow or dry cow	55
Horse	55
Hog	7
Sheep	7
100 chickens	25
100 turkeys	50
	litres per hour
1 cm garden hose with nozzle	900
2 cm garden hose with nozzle	1400

GROUNDWATER

Groundwater is the principal source of water for domestic use and livestock watering in rural areas of Ontario. It is estimated that about 90% of Ontario's farms rely on groundwater for household purposes and 80% use this source for livestock watering. Groundwater is preferred over surface water because minimum treatment is required, long costly pipelines are not needed, the temperature and quality are usually uniform, and the supply is dependable with proper management.

1. OCCURRENCE OF GROUNDWATER

Nearly all groundwater is supplied by precipitation. A portion of the rainfall and snowmelt that enters the soil surface is absorbed by the soil for use by plants. During periods of heavy rainfall, and snowmelt in the spring, water in excess of that absorbed by the soil moves downward towards the water table. The water table is the upper surface of a zone which is saturated. Water in the zone of saturation fills all openings in the formation and is called groundwater.

Formations are referred to as pervious if water moves readily through them, and impervious if little or no water moves through them. Pervious formations such as sand and gravel, or fissured limestone, when they exist below the water table, are referred to as water-bearing formations, or aquifers. These are the formations from which groundwater supplies are obtained.

Figure 1 shows a diagrammatic arrangement of water-bearing formations. When a formation such as fissured limestone is confined between two impervious formations at some great depth below the water table, the water may be under pressure. If it is under pressure, it is known as artesian water. When a well is drilled into an artesian formation, water will rise in the well to a level known as the piezometric level above the formation (Figure 1). If a well is drilled where the piezometric level is above the ground surface, the well will flow and is known as a flowing artesian well.

The level of the water table may vary, being highest following the spring thaw and lowest in the fall of each year. Low water tables frequently occur in February and March just before the spring thaw. The water table can be significantly lowered in local areas by heavy pumping of wells. This has happened in areas near some cities and towns, and intensively irrigated areas. Drainage of swamps will lower the water table locally only to a limited degree because the depth of drainage is usually not great, and will have little effect on deeper groundwater.

Shallow wells which penetrate only a little deeper than the water table will be affected by its fluctuation. If the water table falls too low, the well will become dry. Under these conditions the well can be deepened to correct this trouble if the water-bearing formation extends below the existing well.

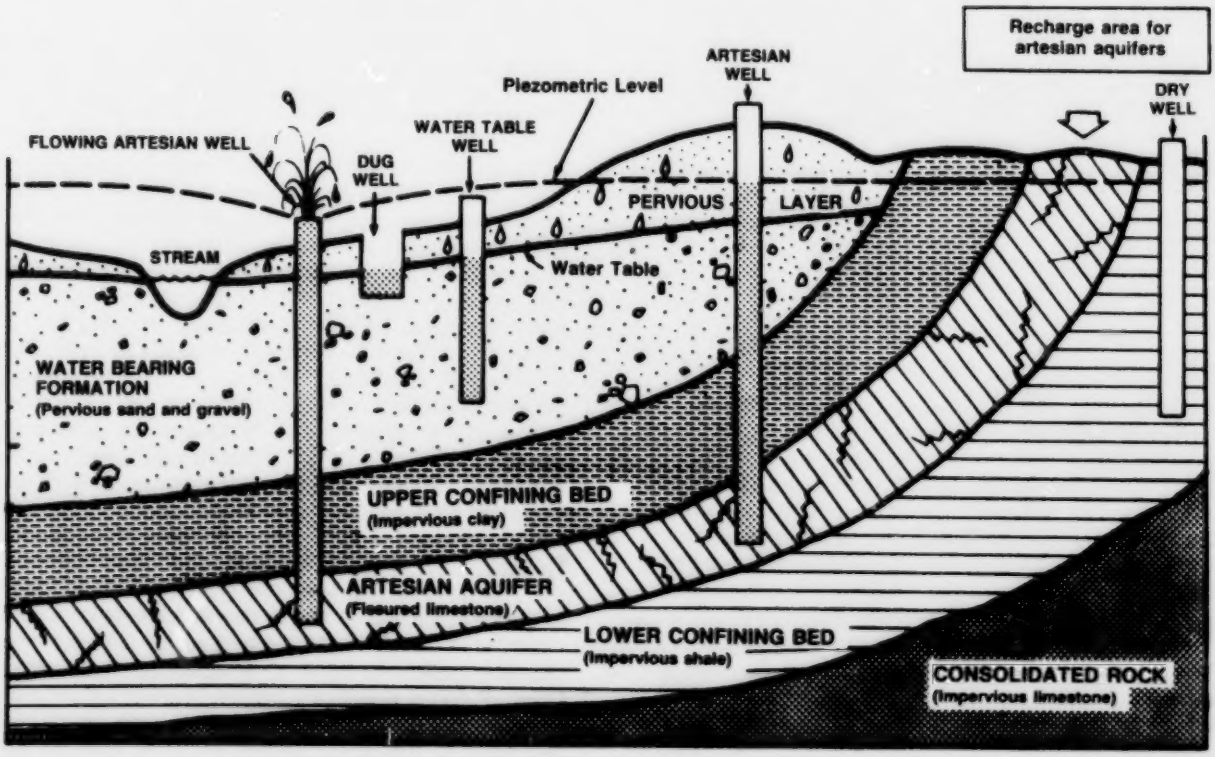


Figure 1. A Cross Section of the Earth Showing a Possible Arrangement of Water-bearing Formations (Gray, 1970)

Usually the most dependable sources of water, particularly where large quantities are required, are the deeper water-bearing formations, tapped by deep-drilled wells. Water from deep sources is usually colder and is less likely to be contaminated than that from shallow sources. However, it usually has a higher mineral content.

2. LOCATING GROUNDWATER

Dependable supplies of water can be obtained simply by sinking wells into suitable water-bearing formations, which, in many areas, extend a great distance in all directions; hence it is not a problem of striking a vein or an underground spring, as is commonly believed. In some areas, where water-bearing formations are not continuous, locating water becomes much more of a problem; in this case, no one can be sure where water will be found, except by drilling test wells. Many claims are made about water-diviners and their ability to locate groundwater, but these claims are entirely without scientific basis and most successful drillers ignore them.

A thorough knowledge of an area helps greatly in locating an adequate groundwater supply. Usually the wells in a locality derive water from the same formation, and the water they yield is often alike in discharge and quality. Local well drillers normally have a good practical knowledge of their district and should be able to decide on the most probable location.

A knowledge of neighboring wells is helpful and can be best obtained by reviewing water well data contained in *Water Resources Bulletins* published by the Ontario Ministry of the Environment. This information originates from water-well records completed by water-well drilling and boring contractors licensed in Ontario. Information such as well location, water levels, well yields, water use and water quality are contained in the bulletins. Copies and/or microfiche of these bulletins are available from the Ontario Government Bookstore or Publications Services. The individual well records may be viewed at the Ontario Ministry of the Environment Regional Offices.

3. PERMIT TO TAKE WATER PROGRAM

The Ontario Ministry of the Environment administers the Permit to Take Water Program. A permit is required for the taking of more than 50,000L of water

TABLE 2

A COMPARISON OF DIFFERENT WELL TYPES AND THEIR APPLICATIONS (MOE, 1980)

WELL TYPE	SUITABLE GEOLOGIC MATERIALS	ADVANTAGES	DISADVANTAGES
DRILLED WELLS	OVERBURDEN AND BEDROCK moderate to high yielding materials (sand, gravel, sandstone, limestone)	1. Can reach deeper depths than other techniques 2. Can penetrate bedrock	1. Generally small diameter wells with little reservoir storage capacity
DUG WELLS	OVERBURDEN both low and high yielding materials (gravel, sand, silt, clay)	1. Does not require special machinery to construct 2. Large diameter provides reservoir storage to augment low yields 3. Can be constructed in areas of limited access	1. Labour intensive to construct 2. Depth is limited because of caving 3. Well failure is common during dry periods because of usually shallow depth
DRIVEN OR JETTED WELLS (Sand Points)	OVERBURDEN moderate to high yielding materials (sand, gravel)	1. Simple installation; can be done by hand or machine 2. A number of these wells can be hooked into one water supply system	1. Small diameter provides little reservoir storage 2. Depth is limited; depends on material in overburden
BORED WELLS	OVERBURDEN both low and high yielding materials (gravel, sand, silt, clay)	1. Efficient method of constructing large diameter wells 2. Large diameter provides reservoir storage to augment low yields	1. Depth is limited because of caving, boulders and bedrock

a day from any source including a well, with the exception of water taken for domestic and livestock purposes.

The permit program is a means of preventing water supply interference problems when possible, and of resolving them when this is not the case. If a new water well under permit interferes with another water supply obtained from an adequate well source in use prior to the issuance of the permit, then the permit holder is required to restore the affected supply or reduce the amount of water taken so as to eliminate the interference. Those who believe that their well is being interfered with by a local water withdrawal should report their case to the appropriate Regional Office of the Ontario Ministry of the Environment. Consideration should be given to possible impact on existing local water uses when a major water well supply is being planned.

4. WATER WELLS

Based on their method of construction, there are four main types of wells: drilled wells, dug wells, driven and jetted wells, and bored wells. A comparison of different well types and their applications are given in Table 2.

4.1 Drilled Wells

Drilled wells are usually the most dependable. These wells are constructed by a well-drilling rig which drills a hole and sets a steel or wrought iron casing.

The function of any well casing is to hold open an excavation down to a suitable water-bearing formation, and to prevent other water (either surface or groundwater) which may be contaminated, from entering the well. Thus the well casing must be constructed of watertight material to a depth below possible sub-surface sources of contamination, and sealed at the top to exclude surface water. If necessary, the well casing should be surrounded by an effective seal of concrete or packed clay so that surface or near-surface contaminated water cannot reach lower uncontaminated groundwater. It is recommended that well casings be a minimum size of 100mm, and preferably 125mm in diameter, to accommodate modern pumping equipment. Drilled wells may be of any depth and often are more than 60m. They are less likely to be polluted and are seldom affected by drought (Figure 2).

A properly constructed drilled well which obtains water from a sand and gravel formation will have a screen installed to allow the entry of water into the well yet exclude the sand and gravel (Figure 2). Such screens are obtainable in varying sizes and lengths, with openings suited to the various grades of water-bearing material. During drilling, samples of the formation are taken and are analyzed to determine the proper size of screen opening to be selected.

After installation of the screen, the well should be developed by pumping or surging to draw the fine material from around the screen into the well, from where it is removed by bailing or pumping. With proper development, a natural envelope of more permeable granular material is produced around the screen which increases the flow of water into the well and yields water free from sand. In some cases, the analysis of the formation material will show that a gravel pack should be placed as a permeable envelope around the screen.

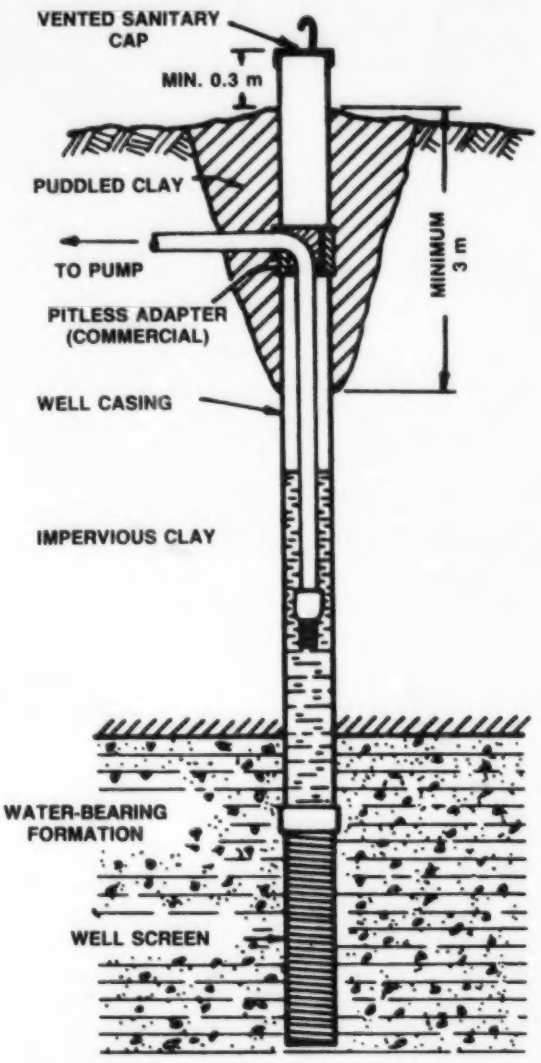


Figure 2. Drilled Well Construction

Local experience may indicate that maintenance of well screens will be required. For example, reduced well yields may be caused by incrustation. This is the deposition of hard minerals, and sometimes slime growth produced by iron bacteria, that clogs the screen and surrounding formation. Redevelopment of the well may help but often treatment is also required with acid or other chemicals to dissolve the minerals, or high concentrations of chlorine to oxidize slime and kill iron bacteria (called shock chlorination). Such redevelopment and treatment requires an experienced well-drilling contractor.

If water is obtained from a rock stratum, a screen is not necessary. However, it is most important that the casing be driven down into and sealed to the rock to prevent soil from entering the well; otherwise, well failure will result in a short time.

4.2 Dug Wells

Dug wells are used in areas where a dependable supply of groundwater exists at a relatively shallow depth and in material which can be excavated by a pick and shovel. Because they are generally dug by hand and all excavated material must be hoisted out of the well, they are seldom more than 10m deep. The diameters of dug wells vary, but they must be great enough for the digger to work conveniently. Hence, these wells are usually 1m or more in diameter. Diameters greater than 1m are of little advantage and add to the costs of the well. However, they do supply added water storage which is important if the flow into the well is weak. Because dug wells usually penetrate only a short distance into the water-bearing formation, many of them dry up when the water table recedes. As a result, many old dug wells are being replaced by more reliable drilled wells.

Dug wells are usually cribbed with concrete or vitrified tile. They are very susceptible to contamination by surface water; therefore, the upper 3m of casing must be set with airtight joints and protected with a concrete cover raised above the surrounding ground level (Figure 3).

4.3 Reconstruction of Old Dug Wells

Dug wells can be reconstructed provided that the water supply is adequate, safe, and conveniently located. If these requirements are not met, it is better to fill it with well-tamped clay to prevent the entrance of surface water and construct a new well. Figure 3 shows one method of reconstruction. The old well should be thoroughly cleaned before reconstruction begins. Dug wells are usually large enough to permit the insertion of concrete or vitrified clay tile and to allow space for fill between the tile and original cribbing. Gravel is placed in this annular space to within 3m of the ground surface. The top 3m of old cribbing should be removed and the space between the tile and the earth filled with puddled clay or concrete after the upper tile joints have been carefully sealed. Installing a water-tight concrete top raised above the surrounding ground level prevents the entrance of surface water.

4.4 Driven and Jetted Wells

A jetted well is made by forcing a high speed jet of water into the ground. Jetting may be done: using drill

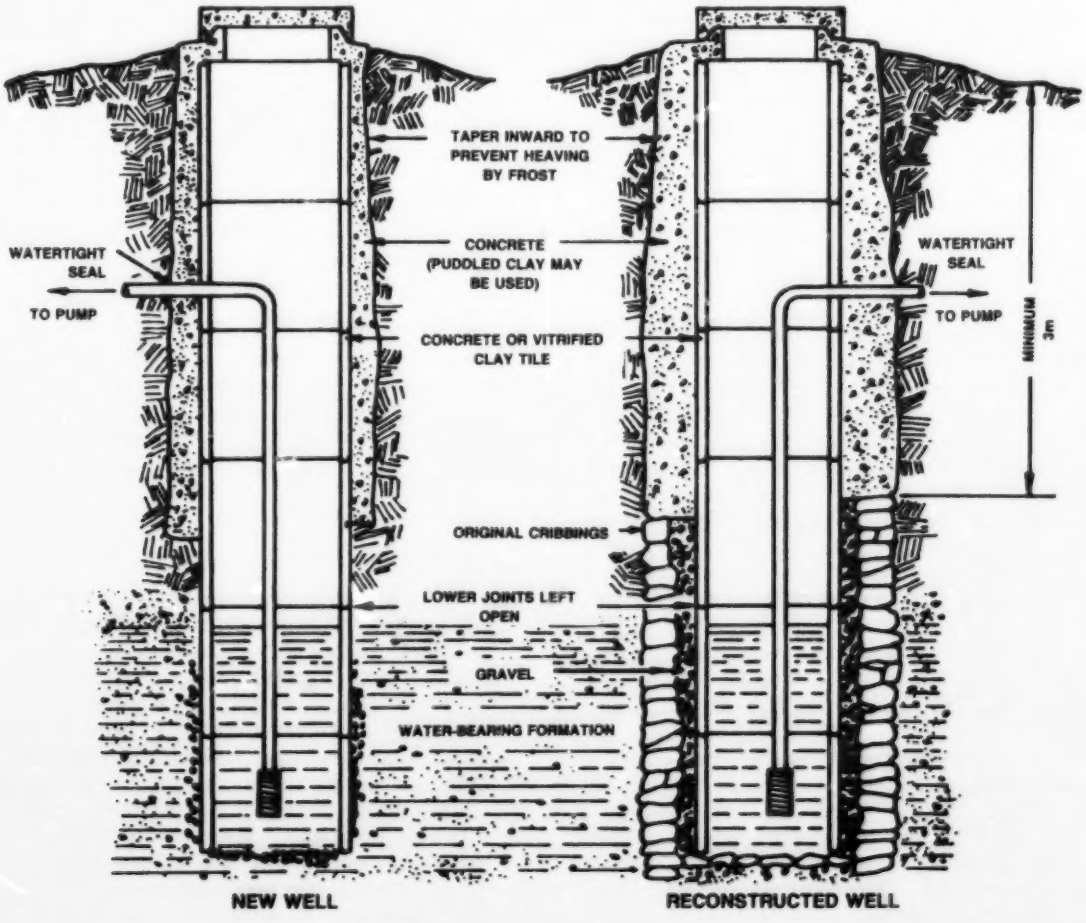


Figure 3. Dug Well Construction

bits to aid the cutting process; sinking a casing that is to remain after the well is completed; or sinking in self-jetting well points. A well point is a well screen threaded to a metal riser pipe. The tip of the well screen will act as the drilling bit. When in place the riser pipe can be connected directly to the pump.

Where the water table in a water-bearing sand and gravel formation exists within 5m of the ground surface and the soil is not too stony, a well point on the end of a pipe can be driven or jetted down into the water. The pipe then serves as the pump's suction pipe. Well points used on driven wells are commonly called drive points and are manufactured for strength to withstand severe driving without damage. As the point is driven into the ground, tests for water can be made by lowering a plumb bob in the pipe or by pumping it. Well points used on jetted wells are constructed with a check valve at the lower end which opens when water flows through a jetting pipe inserted to the lower end of the point. When jetting is stopped, the valve closes to exclude the sand.

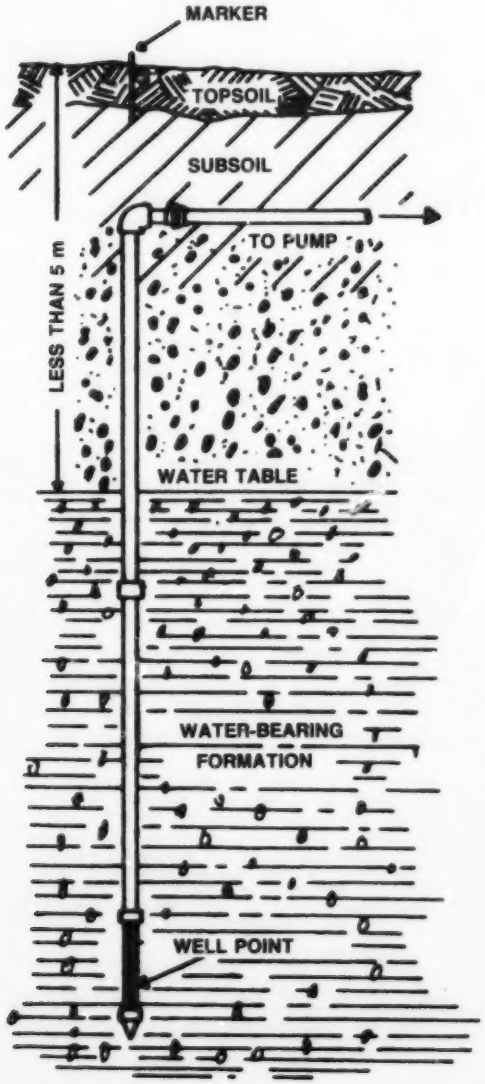


Figure 4. Driven or Jetted Well Construction

Well points vary from 25mm to 100mm in diameter and from 1m to 6m in length, and are covered with a screen to prevent sand from entering the well. Similar to screened drilled wells, the proper size of screen opening should be selected and the well developed to obtain satisfactory performance. It is important that the point is not sunk through the water-bearing formation into impervious material below, particularly when it is being driven. Figure 4 shows a well-point installation that can either be driven or jetted into place.

If more water is required than one point can supply, several points may be placed from 5m to 10m apart and connected into a common suction line to a single pump. One must ensure that there are no air leaks in any of the suction pipes.

Problems associated with quicksand in a dug well can often be solved by installing a well point in the sand formation at the bottom of the well. The well point is connected to the suction pipe leading to the pump. It is important that a representative sand sample be obtained for analysis by the well point manufacturer to select the proper size of screen opening.

4.5 Bored Wells

Bored wells are constructed by earth boring equipment which excavates a borehole into which a casing material such as metal pipe or concrete tile is inserted (Figure 5). Their construction is limited to areas which are free from boulders and where the water-bearing formation is above the bedrock. They range in depth up to 15m and vary in diameter up to 1m. Where the earth material, particularly the water-bearing formation is not very stable, excessive caving occurs making it difficult to construct the well very far below the water table. Under these circumstances, the well will dry up if the water table recedes.

4.6 Location of Wells

In many areas a well can be located on any site that is convenient and safe from pollution. Wherever possible, the well should be located close to the house to simplify the installation of pumping equipment. However, the well should be at least 1m from a building for ease of access in servicing the well and its pumping equipment. It should be far enough from overhead power lines so that the drop pipe, when being removed for maintenance, will not come into contact with them. Contact between the pipe and the power line could electrocute the person holding the pipe.

To minimize the danger of pollution, the well should be on a higher elevation and as far as possible from potential sources of contamination such as privies, septic tank disposal beds, or barnyards. It is recommended that a well be located more than 15m from a possible source of pollution; in open, gravelly soils or shallow limestone, this distance must be greatly increased. Surface drainage must flow away from the well.

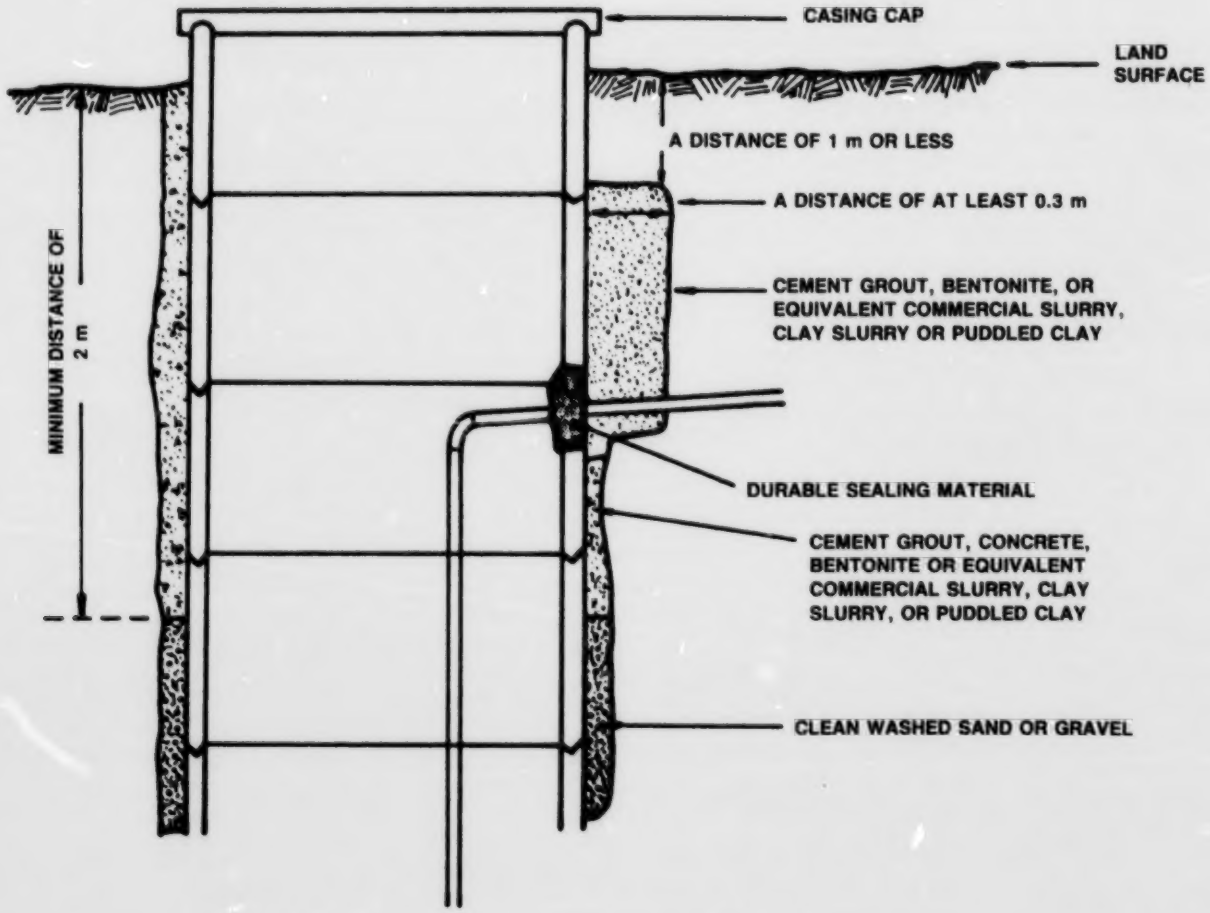

CASING CAP
LAND SURFACE
A DISTANCE OF 1 m OR LESS
A DISTANCE OF AT LEAST 0.3 m
CEMENT GROUT, BENTONITE, OR EQUIVALENT COMMERCIAL SLURRY, CLAY SLURRY OR PUDDLED CLAY
MINIMUM DISTANCE OF 2 m
DURABLE SEALING MATERIAL
CEMENT GROUT, CONCRETE, BENTONITE OR EQUIVALENT COMMERCIAL SLURRY, CLAY SLURRY, OR PUDDLED CLAY
CLEAN WASHED SAND OR GRAVEL

Figure 5. Bored Well Construction (MOE, 1980).

5. SPRINGS

In some localities springs are an important source of water. However, contrary to popular belief, spring water is very likely to be polluted, especially if no precautions are taken to exclude animals and prevent dirt and surface water from contaminating it.

If a spring is above the level of the house and barn, water can be supplied by gravity. If below, water can be raised to the buildings by a pump. However, before equipment for any such supply is installed, the flow of water should be checked to see that it is adequate and dependable and that it is safe for use. The spring should be protected to exclude surface water and fenced to prevent access of livestock (Figure 6). The spring box should be disinfected thoroughly after construction.

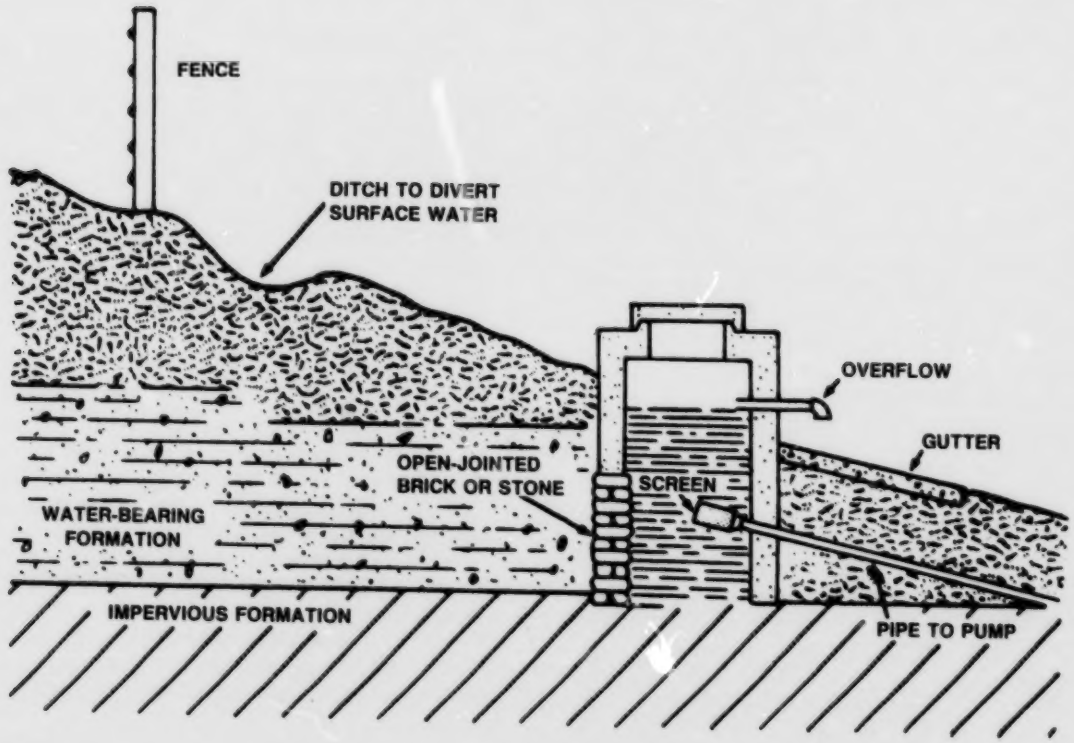


Figure 6. Spring Protection

SURFACE WATER

In some areas where adequate supplies of groundwater are unobtainable, a surface source such as a stream, lake, or specially built pond must be relied upon for part or all of the farm needs. Surface water has been used for years for watering stock, but should only be considered for household use in cases of extreme necessity. It is almost certain to be polluted, is frequently turbid, and may have an unpleasant taste and odour.

If no other supply is available, it may be used for the household, but it must be carefully treated to eliminate the danger of diseases and parasites. The principal steps of treatment that may be required are: (1) coagulation and sedimentation, a chemical treatment that brings tiny particles together into larger aggregates and allows them to settle; (2) filtration to remove any remaining solid particles that are suspended in the water; and (3) disinfection to kill disease-producing organisms.

It must be clearly understood that treatment facilities for surface supplies require continual maintenance, and that the water should be examined at regular intervals to determine its safety. It is beyond the scope of this publication to make specific recommendations for the treatment of all types of surface water, for some supplies may require more elaborate treatment than others. Authoritative advice from the local health officer should be obtained for the treatment of any specific source.

1. PONDS

The following discussion on ponds is based on the information presented in the OMAF Publication 515 entitled *The Construction and Management of Farm Ponds in Ontario.*

Water is collected at times of surplus for use during periods of low rainfall or high demand. Man-made water projects, including the construction of ponds, short-circuit the natural circulation pattern of the waters of the earth.

Where groundwater exists at a shallow depth, a large hole excavated into saturated sand or gravel will provide a type of storage facility that is readily replenished by inflow from the water-bearing strata in the area surrounding the pond. Such ponds are similar to an oversized dug well. This type of pond is common in the sand plains of the tobacco belt of Ontario.

The surface runoff from small drainage areas will prove to be the best water source for ponds in gently rolling or nearly level clay loam or clay soil regions. In most parts of Ontario, surface runoff can be depended upon only during the winter and spring period. The water from melting snow or rain will provide an appreciable volume of runoff from pastureland or cultivated areas. Summer or fall precipitation on such areas result in only a small volume of surface runoff water.

There are several important factors to consider when selecting a site for a pond or determining the feasibility of pond construction. These include the storage type, soil condition, topography, proposed uses, storage requirements, and drainage area.

1.1 Storage Types

Farm ponds can either be excavated or formed by impounding water with a dam or bank of earth. Excavated ponds are more suitable to relatively flat areas and the water storage is provided entirely below the natural ground surface.

Impounded ponds consist of a dam or bank of earth constructed across a valley or depression in such a manner that the storage is primarily above the natural ground level and contained by the banks of the drainage channel and the artificial embankment. On gently sloping areas without well defined drainage channels, or off-stream bypass or pump-filled off-stream ponds, water may be economically retained by combining excavation and above ground impoundment.

1.2 Soil Condition

The soil is probably the most important factor in determining the suitability of a site and the design of a pond. Coarse soils of sand and gravel are highly permeable to water. When groundwater occurs at a shallow depth in such soils it is an advantage, since rapid flow to an excavated pond will result during and after periods of water withdrawal. However, in the case of excavated or impounded reservoirs constructed in dry sand or gravel, the water losses by seepage will be excessive.

Frequently, sites for reservoirs occur on watercourses underlain by sand or gravel with a shallow water table. When proper precautions are taken in the construction of the dam, such sites may be quite satisfactory. Boring test holes with a hand auger or digging test pits should be part of every site investigation. At least four locations should be sampled to a depth of 2m or more on the proposed sites of impounded reservoirs to provide information on the suitability of the soil at the pond site.

On the proposed site for an excavated reservoir, sampling should be carried out to a depth of at least 0.5m beyond the proposed depth of excavation. Typical samples of the soil should be retained, with notes on their depth of occurrence, so that further laboratory tests and opinions of specialists may be obtained in doubtful cases.

1.3 Topography

Land slopes and the drainage pattern will govern the type of pond that can be constructed. As previously indicated, the excavated pond may be constructed on relatively flat or gently rolling clay loam areas. The only real limitation is the provision of a sufficient drainage area to fill the pond.

The impounded type of reservoir is suited to a narrow valley or draw with a gentle grade in the bed of the channel. Where the channel grade is steep, the volume of storage will be small in relation to the size of the dam. If the grade of the channel is nearly level at the margins of the proposed reservoir, an excessive area of shallow pond water will occur. Weed growth will become a major problem at the pond edges unless deepening by excavation is carried out. Choosing a narrow point in the valley for the actual dam site will result in savings in the cost of earth movement.

1.4 Proposed Uses

For the most beneficial use, ponds should be located at or near the point where the water is required. Ponds for livestock water supply should be located close to the barns, or centrally within grazing areas. Water for fire protection should be stored near the farm buildings and be accessible to fire fighting equipment. Location of the irrigation pond within the field or orchard will reduce the costs of pipe and other equipment. Recreational ponds, or those constructed for fish and/or wildlife, should be built to take advantage of natural surroundings. Wasteland may be beautified or made more productive by the construction of a pond. With sound planning in advance of construction, many ponds may be designed and strategically located on the farm to serve two or more purposes.

1.5 Storage Requirements

The pond site selected should provide sufficient storage to meet projected needs and uses. There will be certain unavoidable losses due to seepage and evaporation. Seepage losses can be minimized by careful selection of site with respect to soil. Evaporation losses will be in the order of 0.4m to 0.6m of water depth per year. Practical means for controlling evaporation are not yet available. Fortunately, in Ontario, the rain and snow on the pond surface is more than sufficient to replace these evaporation losses.

Assuming average water losses, the following storage requirements are suggested for ponds filled annually by surface runoff only:

1. Livestock
   a. Cattle
      — drinking only ..2,270L per month per animal
      — drinking plus sanitation.....6,820L per month per animal
   b. Hogs.....450L per month per animal
   c. Sheep .....450L per month per animal
   d. Chickens ....1,360L per 100 chickens per month
   e. Turkeys .....2,270L per 100 turkeys per month
2. Household.....6,820L per person per month
3. Fire protection 454,600L
4. Irrigation.....2,246,600L per irrigated hectare
5. Warmwater fish production .....1,363,800L minimum

1.6 Drainage Area

The runoff-producing characteristics of drainage areas are highly variable throughout Ontario. Soils, land use, and relative amounts of rain and snow vary from region to region and from year to year.

In the areas where snow contributes the bulk of seasonal runoff, one hectare of hay or pastureland can be depended upon to yield at least 280,825 litres of runoff water per year. The yield of snowmelt runoff water from plowed land, corn stubble or winter wheatland will be about 168,490 litres per hectare per year.

Runoff from bushland is very predictable. Where soils are permeable, much of the water from snowmelt soaks into the ground resulting in little or no surface runoff. On rough or rocky ground, the water yield will equal or exceed that of cultivated watersheds.

Drainage from barnyards or other sources of pollution should not be permitted to enter the pond at any time. Advice on the construction of ponds can be obtained from the local offices of the Ontario Ministry of Agriculture and Food or the Ontario Ministry of Natural Resources.

2. CISTERNS

In the past, cisterns were widely used to supply soft water for laundering and bathing. However, with the advent of domestic water softeners, the cistern lost many of its advantages. A softener can be bought for less than the cost of an adequate-sized cistern and shallow-well pump. However, cisterns may still be necessary as a supplementary supply to reduce the demand on the well in cases where the groundwater supply is inadequate. For the same reasons given for other surface water supplies, it is not recommended that cisterns be used for drinking purposes.

To estimate the size of a cistern in cubic metres, multiply the horizontal guttered roof area (outer length of building in metres times outer width of building in metres) by one-seventh. This estimate is based on storing a three month supply of rainfall. For example, if a building is 10m by 12m, the size of cistern should be 10m x 12m x 1/7 = 17m^3. A cistern 10m^2 and 2m deep would be satisfactory. Construction details for a cistern can be obtained from the Canadian Farm Building Plan Service by ordering Plan No. 8440 through your local OMAF agricultural representative.

WATER SUPPLY SYSTEMS

There are two types of water supply systems: the gravity system and the pressure system.

The gravity system is one in which water is pumped into an elevated tank and flows by gravity to the various outlets. While these systems have been installed in the past, their use is generally not recommended. Unless the tank is at least 15m above the outlets, satisfactory pressure is not obtained, and if a stand is required to gain this height the installation can be quite costly.

The electrically operated hydropneumatic system, commonly called a pressure system, is the best type for domestic supplies. Water is pumped into an air-filled storage tank, compressing the air above it until the cut-out pressure is reached. When a tap is opened, the compressed air forces water out of the delivery pipe near the bottom of the tank. As water leaves the tank, the pressure is reduced until the cut-in pressure is reached, at which time more water is pumped into the tank. The pump is started and stopped by a pressure-operated switch. The system is compact and entirely automatic, requiring only periodic lubrication.

The main components of a pressure system are the pump, electric motor, pressure switch, pressure tank, and air-volume control.

1. PUMPS

Hand-operated pumps are still sold and in use in Ontario. Because the problems associated with the selection and installation of hand operated pumps are not difficult, this publication will deal chiefly with power-operated pumps that are more commonly associated with farm water supply systems.

All pumps operate by creating an increased pressure at the outlet and a reduced pressure or partial vacuum at the inlet. This partial vacuum permits atmospheric pressure, acting on the water in the well, to force the water up the suction pipe to the pump. This principle is illustrated in Figure 7-A. When the plunger is raised, the water rises not because the plunger is pulling up on it, but because there is a greater pressure on the water outside the pipe than there is inside it.

Theoretically, it would be possible for atmospheric pressure at sea level to force water up the pipe approximately 10m if the plunger were capable of creating a perfect vacuum. Since no pump is manufactured that can create a perfect vacuum, the practical maximum height that a pumping mechanism can be depended upon is 7m. This maximum height is referred to as the total suction lift of the pump.

When a pump is operating and water is flowing through the suction pipe, the total suction lift of the pump is made up of static suction lift, which is the vertical distance between the water surface and the pump, and the head loss due to pipe friction between the flowing water and the pipe. This is shown diagrammatically in Figure 7-B. The amount of head loss in the suction pipe depends upon the pipe length and diameter, the flow rate through the pipe, as well as the friction coefficient. All reputable dealers in water supply equipment have tables from which the head loss figures in pipes can be obtained.

Head loss must be taken into account where a long suction line on a pump is proposed; the total suction lift must not exceed the practical limit of 7m. For instance, if the vertical distance between the pumping level in the well and the pump (static suction lift) is 5m, the size of suction pipe should be large enough so that the head loss does not exceed 2m, i.e., 5m (static suction lift) + 2m (head loss) = 7m (total suction lift).

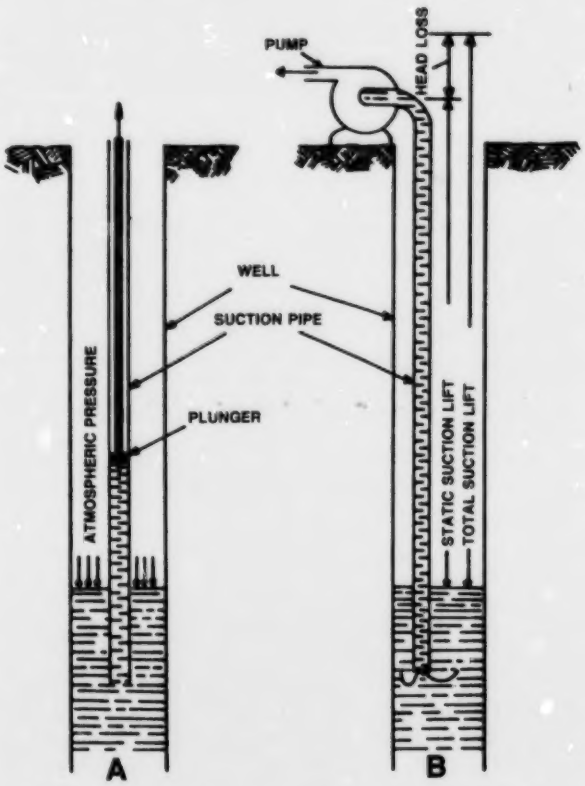


Figure 7. Illustration of Pump Suction Principle

The 7m limit on total suction lift makes it necessary to have two distinct classes of pumps — shallow-well pumps and deep-well pumps. Provided the suction pipe is not excessively long and not small in diameter, a shallow well pump is generally considered applicable where the water level in the well is never more than 7m vertically below the pump. Careful consideration of this limit must be given where the water level is likely to drop during dry periods or when water is being pumped. A deep-well pump is necessary where the vertical distance to the pumping level in the well exceeds 7m. Deep-well pumps must, therefore, have their pumping mechanism placed in, or close to, the water surface of the well.

Shallow-well and deep-well pumps commonly used with farm water supply systems are further classified in-

to different types depending on the pumping mechanisms used in their construction. The different types are as follows:

SHALLOW-WELL PUMPS	DEEP-WELL PUMPS
Reciprocating pump	Reciprocating pump
Centrifugal-jet pump	Centrifugal-jet pump
Helical Rotor pump	Submersible pump

A typical installation and the characteristics of each shallow-well pumping mechanism are shown in Figure 8, and of each deep-well pumping mechanism in Figures 9, 10 and 11. The final selection of all pumps should be made carefully from the manufacturer's Selection Tables to suit the existing operating conditions.

2. ELECTRIC MOTORS

The pump is equipped at the factory with the proper type and size of motor to meet its specified operating conditions. If its replacement is necessary, a reliable dealer or factory representative should be consulted. It is important that adequate-sized wires be used to supply the rated voltage and amperage to the motor, particularly those wires leading to the submersible pump. The manufacturer's specifications should be followed at all times. If the motor does not have a built-in thermal overload device, one should be installed in the motor circuit. All electrical installations should be made by a person who knows the rules and regulations of the Hydro-Electric Power Commission.

3. PRESSURE SWITCHES

The pump operated by an electric motor is always controlled by a pressure-actuated switch. This is pre-set at the factory, generally to start the pump when the pressure in the pressure tank drops to 140kPa (cut-in pressure) and to stop it when the pressure reaches 280kPa (cut-out pressure). These settings may be varied within a limited range, but this should not be attempted by anyone who is not familiar with the mechanism. This is particularly important when the pressure system is equipped with a centrifugal-jet pump because if the pressure settings are raised above those recommended by the manufacturer, the system may fail to operate properly. In case the pressure switch should fail to operate, most positive-acting pumps have a built-in relief valve which opens before dangerous pressures are reached.

4. PRESSURE TANKS

The function of the pressure tank is to store a quantity of water under pressure. Since the presence of air is necessary for the functional operation of the tank, only a portion of the tank provides active water storage capacity; this is the quantity of water between cut-out and cut-in pressure. The active storage is approximately one-fifth of the total tank capacity.

Pressure tanks are made of galvanized steel. Black iron tanks are not recommended because of their short life due to rust and corrosion. Standard tanks are designed for a maximum working pressure of 585kPa but are seldom operated at pressures exceeding 415kPa. A range of tank sizes up to 4,500L capacity is available; tank size selection is discussed in the section on *Selection of Pump and Pressure Tank Capacity.*

5. AIR-VOLUME CONTROLS

Maintaining the proper amount of air in the tank is essential for proper operation of the system. When air and water are in contact with each other under pressure, air is slowly dissolved in the water. It is therefore necessary to add air to the tank. To do this, an air-volume control is installed on the pressure tank to automatically maintain the correct volume of air in the tank at all times. Another method of maintaining the proper amount of air is to prevent contact between the air and water by means of an air bag installed inside the pressure tank.

A waterlogged tank occurs when insufficient air is present. As a result, active storage is reduced and the pump starts and stops frequently. An air-bound tank occurs when too much air is present in the tank; its common symptom is the gushing of water and air from the faucets. Causes of and remedies for these conditions are discussed in the section on *Trouble Shooting.*

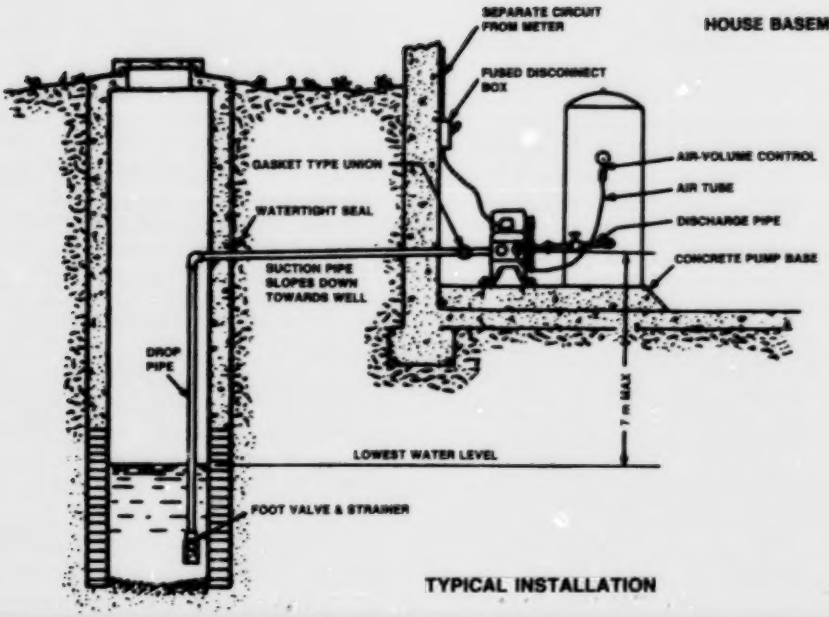
6. SELECTION OF PUMP AND PRESSURE TANK CAPACITY

When selecting the pump and pressure tank, consideration must be given to the demand rate for water on the farm and the well capacity (the rate at which the well will yield water). The well capacity may determine the relative size of the pump and pressure tank required to meet the farm water demand. Hence, the capacity of both the pump and tank should be considered at the same time.

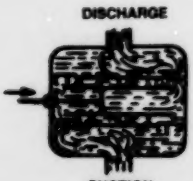
In cases where the well capacity is ample, the first step to determine the pump capacity is to calculate the total daily water requirement of a farm from Table 1 and divide by 2. The next step is to check the adequacy of the pump to meet peak water demands by determining the type and number of water outlets that will probably be opened simultaneously for a prolonged period of time. Manufacturers of pressure systems have tables listing the flow rates of various fixtures which can be used to make this check. For instance, if it is estimated that four faucets which will deliver 15L/min each will be operated at the same time, the peak demand will be 4 faucets × 15L/min × 60 minutes per hour = 3600L/hr. The pump capacity (L/hr) which is selected must meet the greater of the peak demand or the total water requirement of the farm divided by 2.

A further recommendation when dealing with small capacity systems is that a minimum pump capacity of at least 1360L/hr be selected to ensure a reasonable flow of water for fire protection. A pump on a pressure system that supplies 1360L/hr continuously will ensure that water will be available to put out a small fire or provide some protection to other buildings on the farmstead. A final check must be made however, to ensure that the well capacity as determined from a pumping test is equal to or greater than the required pump capacity.

The basis for selecting the size of a pressure tank is a reasonable storage capacity so that on and off cycling of the pump will not be excessive during periods of intermittent water use. The larger the pressure tank, the lesser



TYPICAL INSTALLATION

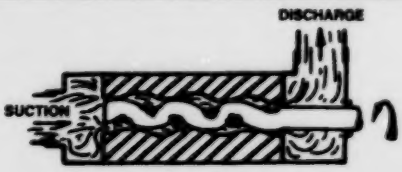


Reciprocating Pump

- Pumping unit can be offset from well.
- Practical maximum total suction lift – 7 m. Self-priming.
- Usually noisier and requires more maintenance than other types of shallow-well pumps.
- Will handle water containing silt and sand in small quantities.
- If it is belt-driven, capacity can be varied within limited range by changing belt pulley size.

Centrifugal-Jet Pump

- Pumping unit can be offset from well.
- Practical maximum total suction lift – 6 m.
- Will handle water containing silt and sand, but jet will wear and reduce efficiency.
- Pumping unit can be converted readily to a deep-well pump.
- Requires little maintenance.



Helical Rotor Pump

- Pumping unit can be offset from well.
- Practical maximum total suction lift – 7 m.
- Must not be run dry as water is essential for lubrication.
- High resistance to wear from pumping gritty material.
- Little maintenance required.

Figure 8. Shallow-well Pumps and their Characteristics

the number of starts and stops and the lesser the wear on the starting switch of the electric motor.

The above procedure for selecting a pump and pressure tank is not satisfactory where the required pump capacity exceeds the well capacity. Under these circumstances the pump must have a capacity somewhat less than the well capacity, a larger storage capacity must be provided and sometimes a second pump will be required. A solution must be worked out for each individual case.

7. INSTALLATION

Proper installation is important for satisfactory performance of a pressure system, and some of the important points regarding this procedure are shown in Figures 8 to 11. However, the manufacturer's instructions should always be followed very closely.

The location of the pressure system should be close to the well, clean and dry, easily accessible, and frostproof. Usually the house basement meets these requirements with the exception of the deep-well reciprocating pump system, where the pumping head must be installed directly over the well. In this case, or if the well is not close to the house, the pressure system should be housed in an insulated pump house (Figure 9). The pump should be placed on a raised concrete platform several centimetres from the floor, and securely bolted down.

On all shallow-well pump installations, it is important that the suction line be at least as large as, if not larger than, the suction connection on the pump. When the distance from the pump to the well is over 18m, the drop pipe and horizontal suction pipe should be one size larger. For greater distances, a reputable dealer should be consulted to determine the size of pipe required. The suction line should be laid in a trench deep enough to be safe from freezing (Southern Ontario—1m; Northern Ontario—2m) and connected to the pump by a union that makes disassembly easy. It should be run as straight as possible from the pump to the drop pipe in the well, with a slight slope downward toward the well. The drop pipe should be long enough so that the lower end is always under water. A foot valve on the end helps to hold the prime.

The above points apply also to the installation of the suction and pressure pipes on the deep-well centrifugal-jet pump. When the pump is off-set from the well, the manufacturer's selection tables should be used to determine the size of pipes required.

It should be emphasized that the submersible pump should not be installed in wells where the water contains

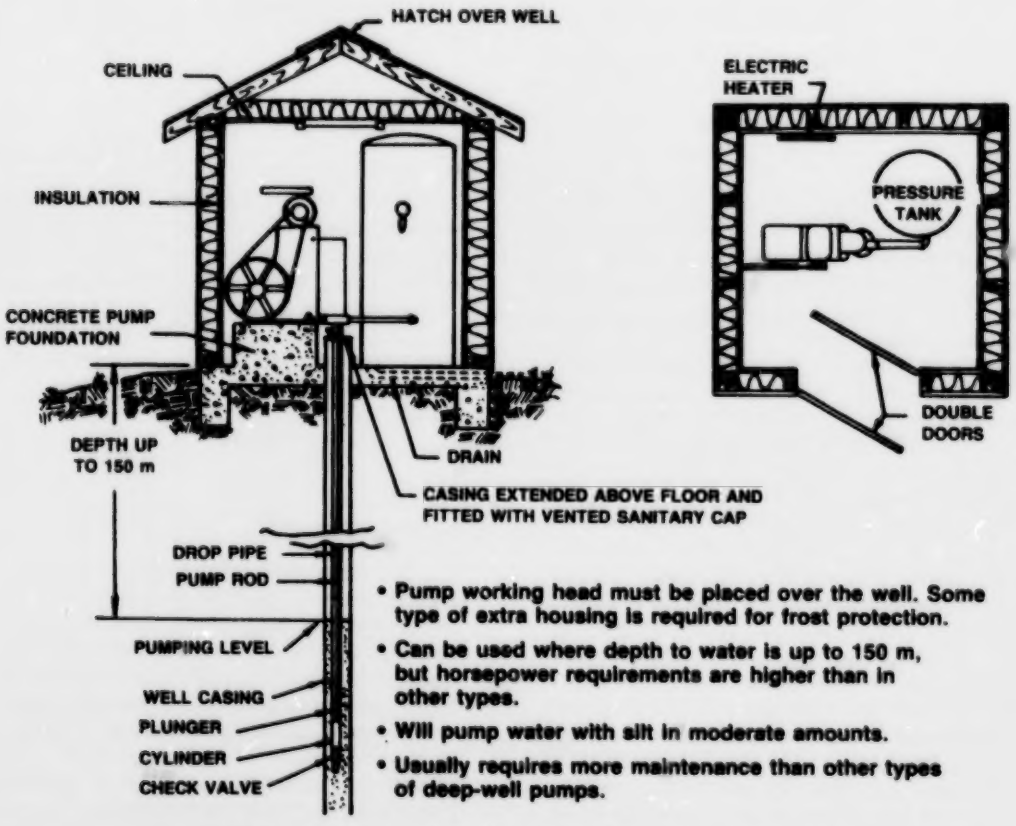

HATCH OVER WELL
CEILING
INSULATION
CONCRETE PUMP FOUNDATION
DEPTH UP TO 150 m
DRAIN
CASING EXTENDED ABOVE FLOOR AND FITTED WITH VENTED SANITARY CAP
DROP PIPE
PUMP ROD
PUMPING LEVEL
WELL CASING
PLUNGER
CYLINDER
CHECK VALVE
ELECTRIC HEATER
PRESSURE TANK
DOUBLE DOORS
• Pump working head must be placed over the well. Some type of extra housing is required for frost protection.
• Can be used where depth to water is up to 150 m, but horsepower requirements are higher than in other types.
• Will pump water with silt in moderate amounts.
• Usually requires more maintenance than other types of deep-well pumps.

Figure 9. Deep-well Reciprocating Pump Installation

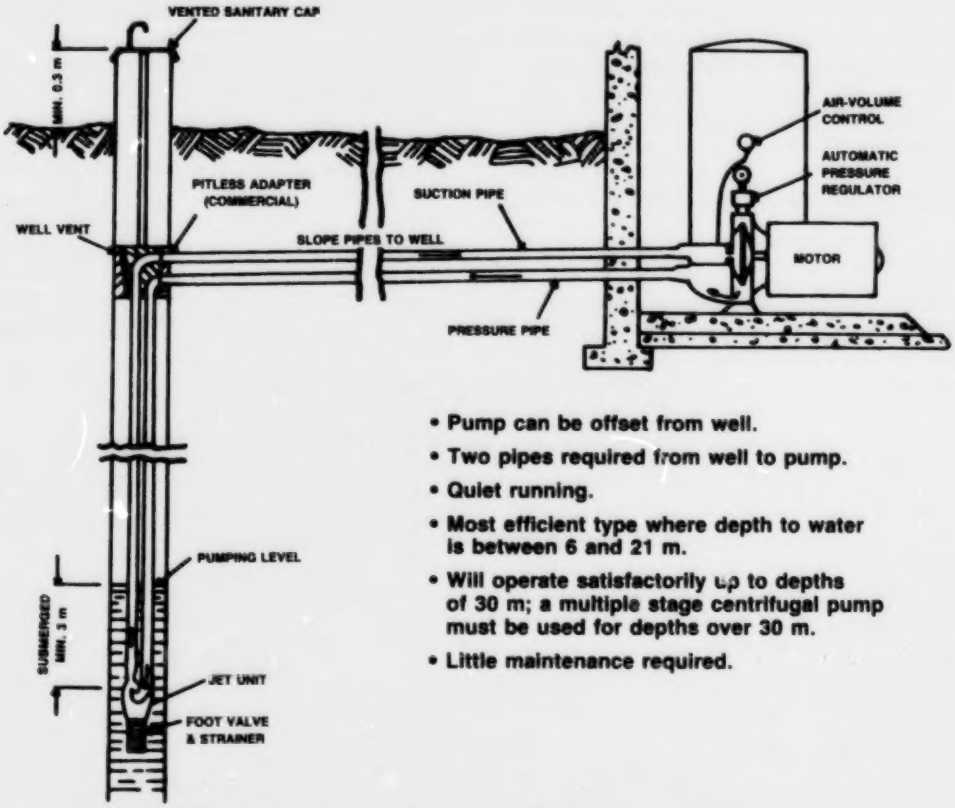

VENTED SANITARY CAP
MIN. 0.3 m
AIR-VOLUME CONTROL
AUTOMATIC PRESSURE REGULATOR
PITLESS ADAPTER (COMMERCIAL)
SUCTION PIPE
WELL VENT
SLOPE PIPES TO WELL
MOTOR
PRESSURE PIPE
• Pump can be offset from well.
• Two pipes required from well to pump.
• Quiet running.
• Most efficient type where depth to water is between 6 and 21 m.
• Will operate satisfactorily up to depths of 30 m; a multiple stage centrifugal pump must be used for depths over 30 m.
• Little maintenance required.
PUMPING LEVEL
SUBMERGED MIN. 3 m
JET UNIT
FOOT VALVE & STRAINER

Figure 10. Deep-well Centrifugal-jet Pump Installation

sand or gas. In addition, the pump should not be operated unless submerged in water. To ensure its submergence at all times, a square-head stop-cock should be installed in the discharge pipe (Figure 11). Before the discharge pipe is connected to the pressure tank, the stop-cock is adjusted so that the pumping level in the well will not drop lower than 3m above the pump. Electrical controls designed to stop the pump when the pumping level becomes dangerously low have not been entirely satisfactory when installed in wells which yield hard water.

Pipe running from the pump to the well can be made of galvanized steel, plastic, or copper. When plastic pipe or copper tubing is used, it is recommended that the same size as that required for steel be installed. There are several types of plastic pipe available; to ensure satisfactory service, the pipe manufacturer should be consulted to select the correct type for any particular pump installation. All plumbing should have as few fittings as possible. Inspection should be made to see that pipe burrs are removed, that the joints are watertight and that no gravel or foreign objects remain in the pipe because they will clog the pumping mechanism. The trench should not be filled until the pump has been run and the suction pipe checked for leaks which will permit air to enter the water and possibly cause a loss of prime.

Pitless adapters can be used on drilled wells to connect the piping from the pressure system to the drop pipe in the well. When properly installed, the pitless adapter makes a watertight junction which prevents surrounding water from entering either the well or the piping system. Adapters are available commercially for different sized drilled wells and for the various types of pressure systems. Sketches are shown of a pitless adapter for a shallow-well pump installation in Figure 2, for a deep-well centrifugal-jet pump installation in Figure 10, and for a deep-well submersible pump installation in Figure 11.

8. MAINTENANCE

An inspection of the system should be made at regular intervals, and the manufacturer's instruction on lubrication and adjustments should be carried out when required. Motors, as a rule, require very little and infrequent oiling. In many cases they are grease-packed in the factory and contain sufficient grease for three to five years under normal operating conditions. Oil-bath pumps must be checked periodically for proper oil level, and oil changed as the manufacturer recommends. Leathers, cylinders, piston rods, and valves on reciprocating pumps will in time become worn and need replacing. The manufacturer's instruction book or a reliable dealer should be consulted for the proper procedure.

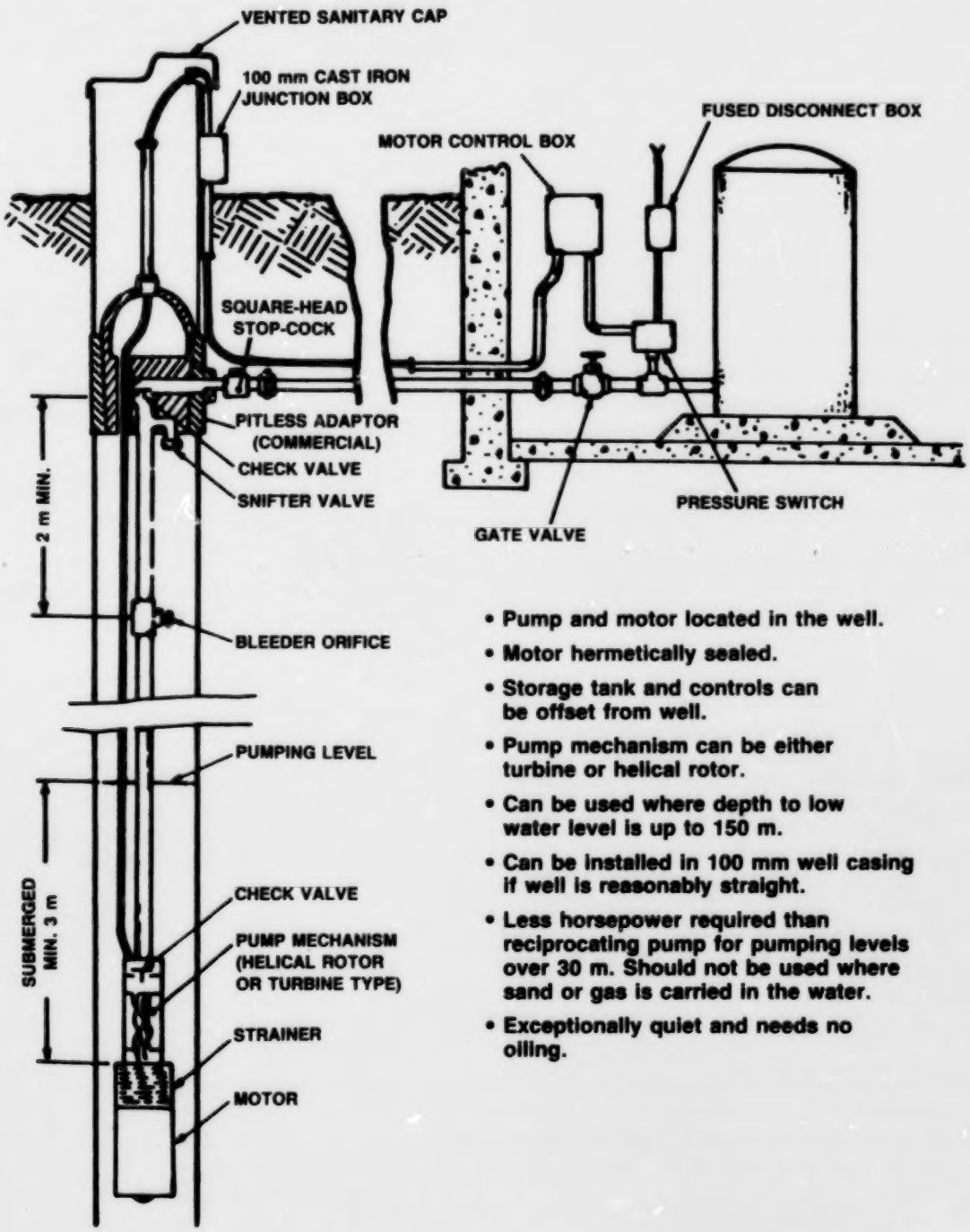

VENTED SANITARY CAP
100 mm CAST IRON JUNCTION BOX
MOTOR CONTROL BOX
FUSED DISCONNECT BOX
SQUARE-HEAD STOP-COCK
PITLESS ADAPTOR (COMMERCIAL)
CHECK VALVE
SNIFTER VALVE
2 m MIN.
BLEEDER ORIFICE
PRESSURE SWITCH
GATE VALVE
PUMPING LEVEL
SUBMERGED MIN. 3 m
CHECK VALVE
PUMP MECHANISM (HELICAL ROTOR OR TURBINE TYPE)
STRAINER
MOTOR
• Pump and motor located in the well.
• Motor hermetically sealed.
• Storage tank and controls can be offset from well.
• Pump mechanism can be either turbine or helical rotor.
• Can be used where depth to low water level is up to 150 m.
• Can be installed in 100 mm well casing if well is reasonably straight.
• Less horsepower required than reciprocating pump for pumping levels over 30 m. Should not be used where sand or gas is carried in the water.
• Exceptionally quiet and needs no oiling.

Figure 11. Deep-well Submersible Pump Installation

9. TROUBLE SHOOTING

It is difficult to set down definite rules for finding a source of trouble. However, a number of common problems are listed below, with suggestions of what to look for if such trouble occurs.

Pump Motor Fails to Start

1. Be sure switch is on and power is not off.
2. Fuse blown.
3. Pressure switch not working. Diaphragm or breaker points need replacing or cleaning.
4. Be sure shaft turns freely. Water seal binding, or scale or ice binding pump mechanism.
5. Wires loose or disconnected at the motor.
6. Motor-starting switch defective, or motor burned out.

Motor Overload Switch Trips Frequently

1. Motor wired for wrong voltage. Check wiring diagram.
2. Motor overloaded due to binding in the pump.
3. Voltage too low. Check voltage at meter and motor when operating. If voltage drop is more than 10 percent, install heavier wiring to motor. If voltage is low at meter, check with power authorities.
4. Motor operating in hot place, not properly ventilated.
5. Pump starting and stopping too often. Check for waterlogged tank.

Pump Runs but Delivers No Water

1. Shut-off valve closed.
2. Water level in well below foot valve.
3. Pump has lost its prime. Re-prime pump. If pump repeatedly loses its prime, the well may be pumped dry periodically, suction line, foot valve, or check valve may be leaking, or suction line may be plugged or have high spot where air accumulates.
4. On reciprocating pumps, one or more valves or valve seats may be faulty (dirty or worn) or pump leather worn. On centrifugal-jet pumps, the jet may be plugged or impeller housing of pump plugged with scale. On a new installation, motor may be turning wrong way, or pressure regulator for jet may not be set high enough to operate the jet at the existing water level.

Pump Starts and Stops Too Often

1. Not enough air in pressure tank. Tank waterlogged. Check tank for leaks above water level. Check air-volume control for faulty valve or stuck float. On deep-well reciprocating pump, air pump may be out of order.
2. Leaky foot or check valve which allows water to run back to well.
3. Bad leak in the plumbing.
4. Pressure tank too small for the demand.

Air Spurts From Faucets

Too much air in pressure tank. Tank air-bound. Repair air-volume control. Check for air leaks on suction side of pump. Check to see that well not being pumped dry periodically.

Pump Delivers Water but Not Rated Amount

1. Low voltage at motor. Pump runs slower.
2. Screen or foot valve obstructed or out of order.
3. Suction pipe too small.
4. Air in suction line. Check for leaks and be sure there are no high spots in line.
5. On reciprocating pumps, pump valves may be leaking, cylinder cracked, or leathers badly worn. Loose belt on belt-driven pumps will allow pump to slow down as pressure increases.
6. On centrifugal-jet pumps, water level may have dropped, jet may be partially plugged, or pressure regulator for jet may be set too low for existing water level.

Jet Pump Fails to Pump Up to Full Pressure and Shut-off

1. Jet partially clogged.
2. Water level dropped too low in the well.
3. Pressure regulator for jet set too low.
4. Adjustment changed on pressure switch, and tank pressure set too high for pump.

Pump is Noisy

1. Bearings or other moving parts of pump loose.
2. Motor or pump loose on mountings.
3. On reciprocating pumps, expansion chamber may be waterlogged. Repair air-volume control on shallow-well pump, or air pump on deep-well pump.
4. On centrifugal-jet pumps, there may be air in the pump due to leak in suction pipe. Some centrifugal pumps make a whirring noise when running; this cannot be avoided.

FARM WATER DISTRIBUTION SYSTEM

A distribution system can be completely installed at one time or, if this is not possible, in parts. However, if it is installed in parts, a plan of the complete system in which all pipe sizes are calculated should be made and followed as each successive part of the system is installed. Plugged tees should be located wherever branches are to be installed in the future, and mains of adequate size used to take care of future expansion. Therefore, when expansion occurs, it will not be necessary to destroy the original installation or be troubled in the future with insufficient pressure. The plan showing the location of all underground pipes should be filed away carefully so that if repairs are necessary, the pipes can be located without any trouble.

1. FARMSTEAD DISTRIBUTION

Pipes that carry water outdoors from the pressure system to the barn, home, or other outbuildings on the farmstead may be either galvanized steel pipe, copper tubing, or plastic pipe. Black iron pipe must never be used because it tends to rust and corrode. The principal disadvantage of galvanized steel pipe is its susceptibility to rust and rupture by freezing. Copper tubing is more costly than steel, but is easier to install and is non-corrosive with most waters. It will also stretch to some extent and is not as readily ruptured when frozen as steel pipe. For underground use, the heavy-duty grade Type K is recommended, and is available in both hard-drawn and soft copper. Plastic pipe is also non-corrosive, light in weight, and easily installed. It is available in lengths up to 120m which reduces the number of fittings required on long distribution lines. Plastic pipe presently being manufactured is suitable only for cold water and will not become damaged from freezing.

Supply pipes to outbuildings must be large enough to ensure satisfactory pressure at the faucet, and must be laid below frost level (Southern Ontario—1m; Northern Ontario—2m) for satisfactory results. The size of pipe which is required depends on the rate of flow through the pipe and the total length of the pipe.

Pipe sizes should be calculated so that the pressure drop between the pressure system and the most remote faucet is not more than 35kPa. Table 3 shows the sizes of galvanized steel pipe which are necessary to maintain satisfactory pressures at the faucets for various rates of flow and various lengths of pipe when a pressure system is used. It should be noted that pipes can be ordered in

TABLE 3
NOMINAL SIZE OF STEEL DISTRIBUTION PIPES*, **

RATE OF FLOW IN LITRES PER MINUTE	LENGTH OF PIPE IN METRES									
	8 (25)[a]	15 (50)[a]	30 (100)[a]	60 (200)[a]	90 (300)[a]	120 (400)[a]	150 (500)[a]	210 (700)[a]	300 (1000)[a]	450 (1500)[a]
25 (5)[b]	21.3mm ½"	26.7mm ¾"	26.7mm ¾"	33.4mm 1"	33.4mm 1"	33.4mm 1"	42.2mm 1¼"	42.2mm 1¼"	42.2mm 1¼"	48.3mm 1½"
45 (10)[b]	26.7mm ¾"	33.4mm 1"	33.4mm 1"	42.2mm 1¼"	42.2mm 1¼"	42.2mm 1¼"	48.3mm 1½"	48.3mm 1½"	48.3mm 1½"	60.3mm 2"
68 (15)[b]	33.4mm 1"	33.4mm 1"	42.2mm 1¼"	42.2mm 1¼"	48.3mm 1½"	48.3mm 1½"	60.3mm 2"	60.3mm 2"	60.3mm 2"	73.0mm 2½"
90 (20)[b]	33.4mm 1"	42.2mm 1¼"	42.2mm 1¼"	48.3mm 1½"	60.3mm 2"	60.3mm 2"	60.3mm 2"	73.0mm 2½"	73.0mm 2½"	73.0mm 2½"
136 (30)[b]	42.2mm 1¼"	42.2mm 1¼"	48.3mm 1½"	60.3mm 2"	60.3mm 2"	73.0mm 2½"	73.0mm 2½"	73.0mm 2½"	88.9mm 3"	88.9mm 3"

**Metric units for nominal pipe sizes in the table are given for outside diameter.*
***Refer to text for copper and plastic pipe sizes.*
[a]*Units in feet.*
[b]*Units in gallons per minute.*

Note: Precaution should be taken when purchasing pipes because imperial units are still in use.

metric or imperial units. If plastic pipe is to be used, it is recommended that Table 3 be used for sizes up to 33.4mm. If the required steel pipe size is greater than 33.4mm, the next smaller size plastic pipe may be used in its place. When copper pipe is used, the size should be selected from Table 3 because the actual inside diameter of copper tubing is less than that of steel pipe for each nominal size. These suggested rules for copper and plastic pipe apply mainly to distribution lines greater than 8m in length.

For most farms, it is suggested that the size of the distribution main be calculated for a maximum flow of 45L/min, and for individual branches to waterers, hose faucets, etc., for a maximum flow of 25L/min. On farms where the water requirements are so great that a pump capacity of over 2700L/hr is recommended, the size of the distribution main should be calculated for a flow equal to, or somewhat greater than, the pump capacity in litres per minute.

For example, in the system shown in Figure 12, the pipe from the pressure system past the poultry house to the dairy barn is 60m long, and should be capable of maintaining a flow of 45L/min. From Table 3, a 42.2mm steel pipe is required for a flow of 45L/min through 60m of pipe. If plastic pipe is used, a 33.4mm size would be satisfactory. The individual branches to the water trough, poultry house, and hydrant at the machine shed are all less than 30m long, and should be capable of a flow of 25L/min; Table 3 shows that 26.7mm pipe would be suitable. If the distance were less than 8m however, 21.3mm pipe would be satisfactory.

Before being covered, all underground pipe should be carefully joined and tested to ensure long, trouble-free service. If possible, the pipe should be laid on a slight slope upward from the pump so that it may be drained if necessary.

2. DISTRIBUTION WITHIN BUILDINGS

It is recommended that all plumbing within buildings be installed by a person who is familiar with the Ontario Plumbing Code. House plumbing is generally either galvanized steel pipe or copper tubing. Plastic pipe at present is not permitted for hot water use. Steel pipe or hard-drawn copper is used extensively in new buildings. The flexible nature of soft copper tubing makes it advantageous when the plumbing is being remodelled or extended because it is more easily handled than rigid pipe. The standard grade (Type L) of copper tubing is generally used for indoor plumbing. A diagrammatic house distribution system is shown in Figure 13.

The pipe sizes are based on the use of galvanized steel pipe. Where copper tubing is used and the lengths involved are less than 8m, it may be possible to reduce the pipe

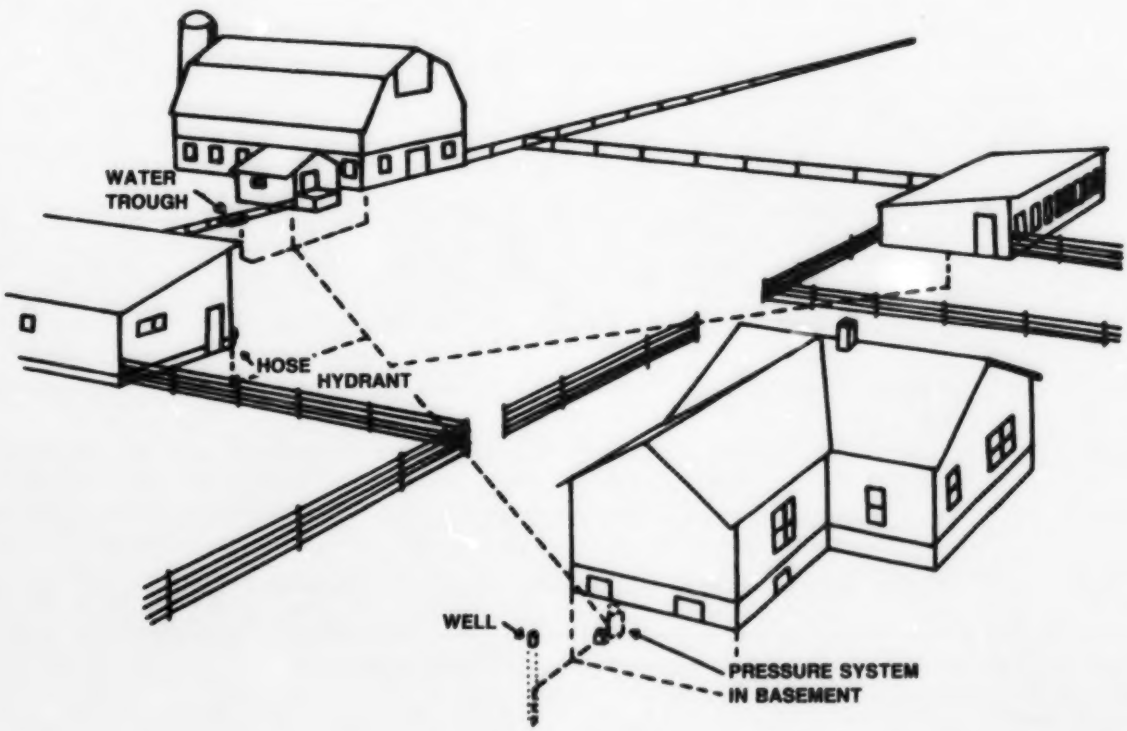


Figure 12. Farmstead Distribution System

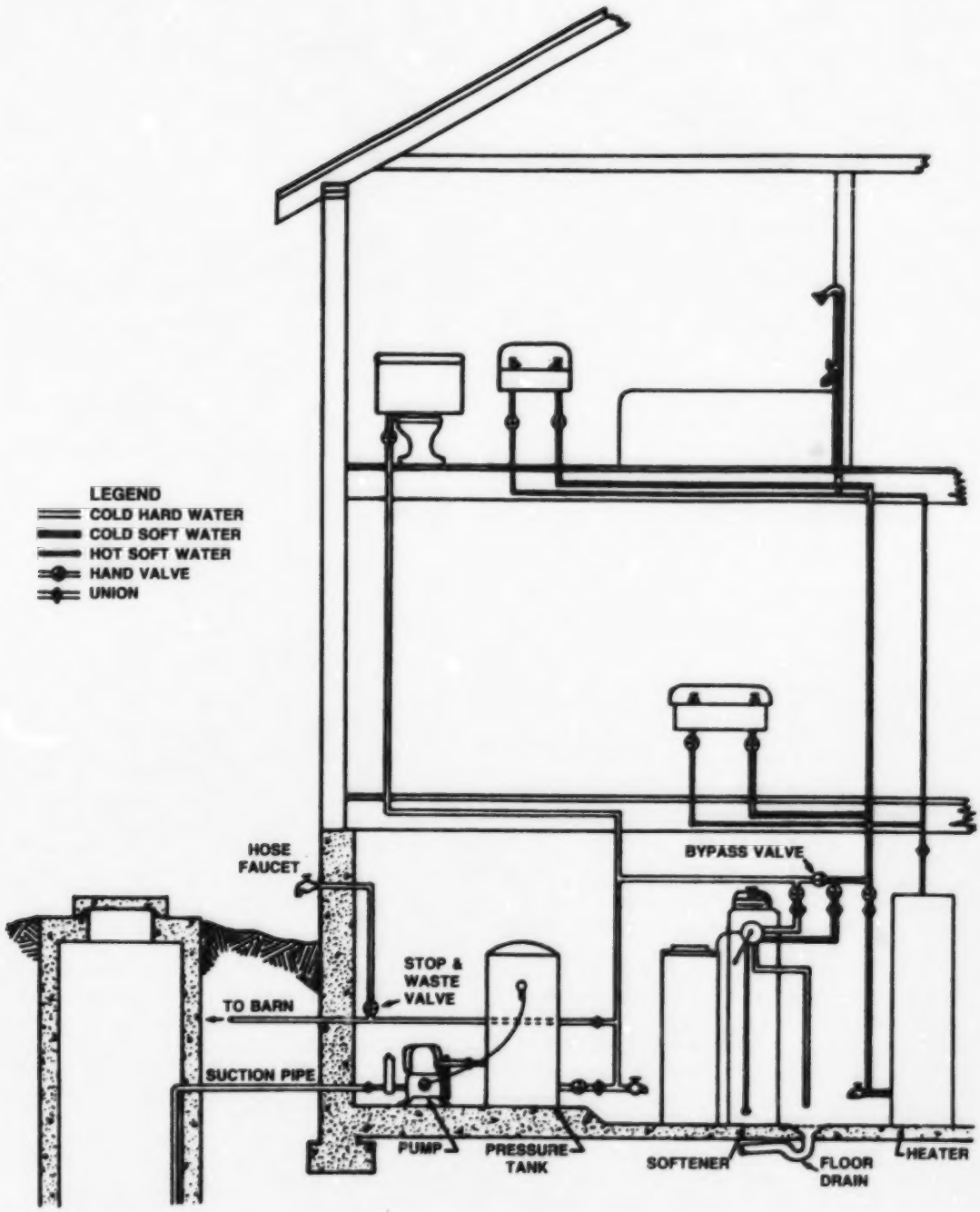


Figure 13. House Distribution System

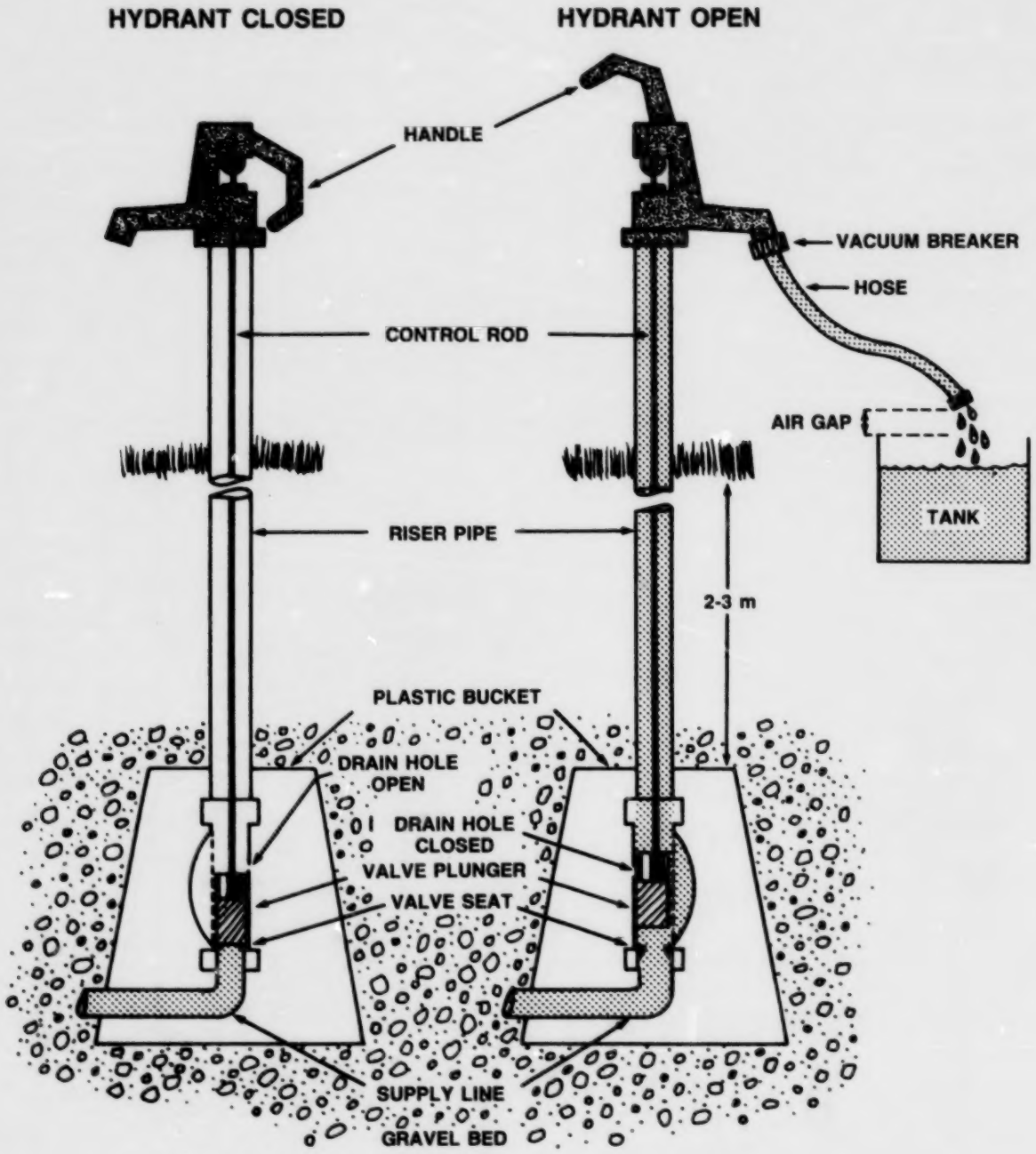


Figure 14. Frost-Free Yard Hydrant (Alberta Agriculture, 1978)

sizes by one size. All plumbing fixtures should be installed as close together as possible to reduce the pipe cost.

Plumbing in buildings housing livestock may be steel, copper, or plastic pipe. Plastic pipe, however, must be installed so that it is protected from mechanical damage such as tramping or chewing by livestock. In addition, it must be fully supported throughout its length.

Automatic waterers are available for all types of livestock; in addition to usually being more sanitary, they reduce labor, ensure an adequate supply at all times, and save water. Frost-proof automatic watering bowls have proved to be a great convenience in the feed lot or barn. The bowl is equipped with a thermostatically controlled heating element to prevent the water in the bowl from freezing. In buildings where there is danger of the pipes freezing, especially where automatic waterers are used, electric heating cable can be installed on the water pipe. A thermostat set at about 2°C is placed in the circuit so that the heating cable operates only when the pipes are in danger of freezing. Details on installation can be obtained from most electrical manufacturers.

3. OUTSIDE OUTLETS

Outdoor hose faucets are a necessity on every farm. A hose can be used not only for watering gardens and lawns, but also for washing automobiles and machinery, and may be invaluable in case of fire. Because outdoor faucets are exposed to frost, they must be arranged so that they can be drained easily when not in use.

A simple method of draining sill cocks is shown in Figure 13. A stop and waste valve is installed on the branch inside the house. When winter approaches, the stop and waste valve is closed and the hose faucet is opened, allowing the water to drain out of the waste opening.

This method is inconvenient if water is required all year round. In this case, a frost-free yard hydrant is more satisfactory (Figure 14). The following discussion of frost-free yard hydrants relies on an Alberta Factsheet, entitled *Frost Free Yard Hydrants* Agdex 716 (C51).

Frost-free hydrants are installed to provide water to various locations in the farm yard during all seasons of the year. They are manufactured and installed in such a way that they will operate throughout the winter without auxiliary heat.

A major component of a hydrant is a stop and drain valve. This valve is located below frost level—usually 2m to 3m below the ground surface. The valve is operated by a lever or wheel which is connected to the valve by a control rod. When the valve is open, water flows from the supply line, through the valve, up the riser pipe, and out through the head of the hydrant. When the valve is closed, the flow of water stops and a drain hole in the valve opens. The water in the riser pipe flows out of this drain hole into a gravel bed, leaving the riser pipe empty and preventing ice formation.

It is important that the riser pipe drain quickly during cold weather to minimize the formation of ice inside the riser pipe. At least 1m of clean coarse gravel must be placed around the stop and drain valve of the hydrant. A container such as a heavy plastic bucket placed upside down around the valve will also aid the quick draining.

The hydrant should be installed so that it will allow:

1. unrestricted flow when the valve is open;
2. no seepage past the valve when it is closed;
3. proper draining of the riser pipe when the valve is closed; and
4. no leakage through the drain hole when the valve is open.

The location of hydrants is also an important consideration. They should be located where they will not be subject to damage by livestock or machinery. They should never be installed in or near wells or pump pits since drainage from the hydrant can contaminate the well or flood the pump pit. For example, the end of a hose which is being used to fill a sprayer tank may become submerged in the chemical solution. If the hydrant is shut off and starts to drain, a siphoning action will be started and the chemical from the sprayer tank will be siphoned into the drainage area. If the hydrant drains into the well casing or well pit, this may result in considerable contamination. An air gap must always be kept between a hose outlet and the highest possible water level in any tank. Anti-siphon or vacuum breaker valves are available for hydrants which will help prevent this very common type of accident.

If a hydrant is to be used frequently during summer months, it may be advantageous to put a hose bib or globe valve on the outlet of the hydrant. The hydrant valve can then be left open over the summer and the gravel bed will remain dry to allow better winter drainage.

If a hydrant is used in winter a large volume of water, 100 to 150L, should be drawn off occasionally. This melts the layers of ice which can build up in the riser pipe.

A hydrant can freeze due to improper valve adjustment; a saturated drainage bed; a plugged drain hole; improper use, such as incomplete shut off or the constant withdrawal of only small amounts of water. If a hydrant freezes, it should be thawed as soon as possible to avoid damage. A hydrant which is frozen above ground level, can be thawed by heating with an electric heat tape, a torch or hot water. If the hydrant is frozen below ground level, the head will have to be removed and hot water poured down the inside of the riser pipe.

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